

JAPANESE PATENT OFFICE (JP)

PATENT JOURNAL (A)

KOKAI PATENT APPLICATION NO. HEI 3[1991]-45768

Int. Cl. ⁵ :	D 04 H 1/42 //D 06 C 7/00
Identification code:	
Sequence Nos. for Office Use:	T 7438-4L Z 7199-4L
Application No.:	Hei 1[1989]-178870
Application Date:	July 10, 1989
Publication Date:	February 27, 1991
No. of Inventions:	3 (Total of 5 pages)
Examination Request:	Not requested

A MELT-BLOWN NON-WOVEN FABRIC AND MANUFACTURING METHOD THEREOF

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[There are no amendments to this patent.]

Specification

1. Title of the invention

A melt-blown non-woven fabric and manufacturing method thereof

2. Claims of the invention

(1) A melt-blown non-woven fabric made of polyethylene terephthalate melt-blown fiber having a crystallinity of 30% or below and having a shrinkage factor on a hydrothermal plane of 20% or below.

(2) The melt-blown non-woven fabric specified in claim 1, in which the mean diameter of the polyethylene terephthalate melt-blown fiber is 5 μm or less.

(3) A manufacturing method for the melt-blown non-woven fabric in which a dry heat treatment is provided for a non-woven melt-blown fabric made of a polyethylene terephthalate fiber melt-blown at a temperature of 180°C or below to produce a melt-

blown non-woven fabric with a shrinkage factor on a hydrothermal plane of 20% or below.

3. Detailed explanation of the invention

<Field of industrial application>

The present invention pertains to a non-woven fabric that can be used effectively for clothing, as a gas-permeable or liquid-permeable filter material, or as an oil separation material, and the invention further pertains to a melt-blown non-woven fabric with excellent moldability based on a low thermal shrinkage factor, good dimensional stability, high flexibility and high elongation, and a manufacturing method thereof.

<Prior art>

In a method wherein a molten polymer is discharged from an orifice and at the same time, a hot-air current is applied and spinning is performed to produce a fine fiber and the fiber is collected on a conveyer to produce a non-woven fabric (melt-blow method), a non-woven fabric made of a super-fine fiber, which is less likely to be achieved when a different method is used, can be produced directly.

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In order to produce a non-woven fabric having a uniform fine fiber using the melt-blow method, it is necessary to discharge of the polymer at a viscosity lower than the viscosity commonly used for standard hot-melt spinning, and when a polymer with a stable low viscosity is used, many polymers can be made into a fabric using the melt-blow method or a similar method. The flexibility of the polymer is one of the major advantages of the melt-blow method and attempts are being made to produce non-woven fabrics using many different types of polymers such as polyolefins, polyethylene, polyamide, and polyurethane.

Among those listed above, polyetheylene terephthalate is a standard synthetic fiber material having many advantages such as hydrophilic properties, dye affinity, etc., and is widely used as a filter material, an oil separation material, and for making clean room clothing, synthetic leather materials, etc.

In a non-woven fabric produced by melt-blowing of a polyetheylene terephthalate, the material remain amorphous right after spinning, thus, when heating is performed for the web produced, shrinkage occurs in the web due to the residual stress in the fiber that comprises the web. Assuming that shrinkage of the web can be eliminated upon crystallization of the polyetheylene terephthalate fiber, an attemp was made by the inventors to perform a heat treatment under a constant length. In the above-mentioned method, a treatment is provided for the

web made of an amorphous fiber for a long time at a temperature above the glass transition temperature of the polymer after spinning so as to complete the crystallization and to provide dimensional stability, but achievement of dimensional stability under the above-mentioned conditions is accompanied by the problems described below, as well.

The major disadvantage of the above-mentioned method is weakening of the non-woven fabric caused by thermal crystallization. When thermal crystallization is carried out for a non-woven fabric made of an amorphous fiber produced by melt-blowing method, it is not possible to stretch each fiber of the structure, as a result, spherite is likely to form and elongation of the non-woven fabric after the treatment is likely to be inadequate. For this reason, handling of the sheet after the heat treatment becomes a problem, and, for example, rupturing occurs easily when pleats are formed, which are commonly used in the molding of a filter by a machine.

In general, when molding process such as pleating is performed, in addition to thermal dimensional stability, strength and flexibility are required for the web as well and it has not been possible to produce a material with a good balance of these properties when the above-mentioned standard melt-blow spinning or standard thermal dimensional stability treatment is performed alone.

In other words, a polyethylene terephthalate melt-blown non-woven fabric having good thermal dimensional stability as well as excellent flexibility and high elongation does not exist.

<Problems to be solved by the invention>

Based on the above background, the inventors carried out considerable research into the production of a non-woven fabric having good thermal dimensional stability and flexibility as well as high elongation strength unique to melt-blown non-woven fabrics made using polyethylene terephthalate, and as a result of their effort, the present invention was accomplished.

The objective of the present invention is to produce a melt-blown non-woven fabric with excellent moldability based on a low thermal shrinkage factor, good dimensional stability, and high flexibility and high elongation and to provide a manufacturing method thereof.

<Means to solve the problems>

Thus, the melt-blown non-woven fabric of the present invention is a melt-blown non-woven fabric made of a melt-blown polyethylene terephthalate fiber having a crystallinity of 30% or below and having a shrinkage factor on a hydrothermal plane of 20% or below.

Furthermore, the feature of the manufacturing method of the melt-blown non-woven fabric of the present invention is that a dry heat treatment is performed for a melt-blown non-woven fabric made of a melt-blown polyethylene terephthalate fiber at a temperature of 180°C or below to produce a melt-blown non-woven fabric with a shrinkage factor on a hydrothermal plane of 20% or below.

<Effect of the invention>

In the present invention, crystallization is carried out for a melt-blown non-woven fabric, but the thermal dimensional stability is controlled during the crystallization process so that a state at or below a saturated crystallization state is achieved, ideally a crystallization of 30% or below, to produce a polyethylene terephthalate melt-blown non-woven fabric with high flexibility and high elongation. The melt-blown non-woven fabric of the present invention and the manufacturing method thereof are explained in further detail below.

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Properties, in particular, thermal dimensional stability, flexibility, and high elongation, of a melt-blown non-woven polyethylene terephthalate fabric are strongly affected by the crystallinity of the non-woven fabric. The crystallinity of the

melt-blown non-woven polyethylene terephthalate fabric right after spinning is very low, approximately 6%. The high flexibility of the polyethylene terephthalate melt-blown non-woven fabric right after spinning is based on the amorphous state of the polymer comprising the majority of the fiber. On the other hand, when a relaxation treatment is provided under heat for the above-mentioned non-woven fabric, the amorphous area softens and significant shrinkage occurs due to the residual stress in the fiber caused by the absence of a skeletal structure that controls shrinkage of the fiber, resulting in poor thermal dimensional stability.

Furthermore, due to the low fiber strength of each fiber, the strength of the non-woven fabric is low and it is easily deformed upon application of an external force.

On the other hand, when crystallization is performed using a heat treatment under a constant length, in general, saturated crystallization of approximately 40% can be achieved and the material exhibits sufficient thermal dimensional stability. However, in general, the fiber used for a melt-blown non-woven fabric is similar to a non-stretched filament, thus, when a heat treatment is performed, spherite is likely to be produced and strength, flexibility, and elongation become inadequate.

In this case, the crystallinity can be easily measured by the density method and in the case when many different types of

modifiers are included in the polyethylene terephthalate, it is necessary to compensate for the change in specific gravity based on the modifiers.

In the present invention, the crystallinity of the melt-blown non-woven polyethylene terephthalate fabric is higher than the crystallinity right after spinning, but the degree of crystallinity is kept at or below the saturated state, ideally, 30% or below, so as to provide flexibility and high elongation.

In the following, the effect of the present invention is explained further with reference to the figures. Fig. 1 shows the relationship between crystallinity and shrinkage factor on a hydrothermal plane and elongation and as a function of treatment time when a dry heat treatment is applied to a melt-blown non-woven polyethylene terephthalate fabric having a shrinkage factor on a hydrothermal plane of 70% without heat treatment.

As shown in Fig. 1, the shrinkage factor on a hydrothermal plane of 70% is reduced to 20% or below within several seconds after starting the heat treatment, and an increase in the thermal dimensional stability can be observed. Furthermore, the shrinkage factor on a hydrothermal plane is rapidly reduced with time and a factor of 4% was achieved after 1 minute. The crystallinity in this case is approximately 6%, and hardly any difference was observed in the crystallinity after versus the

crystallinity before the heat treatment when the density method was used for measurement.

The elongation of the non-woven fabric is reduced with an increase in the treatment time, but the degree of reduction is somewhat moderate compared with that of the shrinkage factor on a hydrothermal plane, and the time when a constant elongation factor is achieved, in other words, the time when the elongation is reduced to the same level as the non-woven fabric that reached a saturated state of crystallinity, is when the crystallinity of the non-woven fabric reaches approximately 30%.

As described above, when a heat treatment is performed for a melt-blown non-woven polyethylene terephthalate fabric and the crystallinity is adjusted to 30% or below to produce a melt-blown non-woven polyethylene terephthalate fabric having a low shrinkage factor on a hydrothermal plane and good elongation.

As shown in Fig. 1, when the crystallinity of the fiber is 30% or higher, the elongation of the non-woven fabric is insufficient. The above-mentioned non-woven fabric with excess crystallinity lacks flexibility and has a paper-like texture.

It is desirable for the mean diameter of the fiber of the melt-blown non-woven polyethylene terephthalate fabric of the present invention to be 5 μm or less, and 3 μm or less is preferable. When the mean fiber diameter is greater than 5 μm ,

the degree of orientation of the molecular chain in the fiber is insufficient at the time of spinning, and spherite is likely to be produced during crystallization due to heating and the fiber becomes brittle; thus, the effect of the present invention cannot be achieved.

In this case, the mean fiber diameter is obtained by taking a photograph of any given position on the non-woven fabric by a scanning electron microscope (SEM), and the mean value of the fiber diameter for at least 100 fibers selected at random is determined.

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It is desirable for the metsuke of the polyetheylene terephthalate melt-blown non-woven fabric of the present invention to be in the range of 10 g/m^2 and 100 g/m^2 . When the metsuke is less than 10 g/m^2 the degree of entanglement among the fibers is inadequate; thus, slipping of the fibers relative to each other is likely to occur during the heat treatment process; on the other hand, when the metsuke is greater than 100 g/m^2 , a uniform heat treatment in the thickness direction is less likely to be achieved, which is not desirable.

It is desirable for the pore volume of the melt-blown non-woven polyetheylene terephthalate fabric of the present invention to be 95% or below. When the pore volume is greater than 95%,

the degree of entanglement among fibers is inadequate and slippage of the fibers is likely to occur.

The polyethylene terephthalate melt-blown non-woven fabric of the present invention can be used by itself or in the form of a laminate with other non-woven fabrics, woven materials or mesh-like materials.

When a dry heat treatment is performed for the polyethylene terephthalate melt-blown non-woven fabric after spinning to produce a melt-blown non-woven polyethylene terephthalate fabric having a crystallinity of 30% or below and a shrinkage factor on a hydrothermal plane of 20% or below resulting in the non-woven fabric of the present invention, it is desirable to perform a heat treatment at a temperature of 180°C or below. When the temperature used at the time of heat treatment is high, crystallization can be achieved in a short time, and when the temperature used for the heat treatment is low, crystallization requires a long time, but when the temperature at the time of the dry heat treatment is greater than 180°C, crystallization occurs in too short of a time and precise control of the crystallinity is difficult to achieve.

Furthermore, in order to achieve a balance between productivity and crystallinity, it is desirable to perform the treatment at an appropriate temperature. For example, a

temperature in the range of 100°C to 170°C, but a temperature in the range of 110°C to 160°C is preferable. In addition to the using the above-mentioned temperature, when the treatment time is controlled appropriately in the actual production, a material with a crystallinity of 30% or below, as specified in the present invention, can be produced with relative ease.

Needless to say, the treatment used for the non-woven fabric of the present invention is not limited to the above-mentioned dry heat treatment, and other heat treatment methods (wet treatment, steam treatment, etc.) can be used as well.

<Effect of the invention>

The non-woven fabric of the present invention has excellent thermal dimensional stability and is flexible and has high elongation as well; thus, it can be used effectively for clean room clothing, synthetic leather materials, etc. Furthermore, when heat is applied to the melt-blown non-woven fabric of the present invention, after the treatment, shrinkage and wrinkle formation do not occur, thus, the non-woven fabric can be used effectively in fields where heat is used.

<Application examples>

Application Example 1

A heat treatment was performed for a melt-blown non-woven fabric made of a melt-blown polyethylene terephthalate fiber with a mean fiber diameter of 2.5 μm and a metstuke of 40 g/m^2 under constant length at a temperature of 120°C for 30 seconds. The crystallinity of the resulting non-woven fabric was 4% and the thermal shrinkage factor was 12%. The stress-strain curve for the resulting non-woven fabric is shown in Fig. 2a. The non-woven fabric produced exhibits excellent flexibility as well as having excellent elongation properties as shown in Fig. 2, as a result, molding could be carried out effectively without rupturing.

Application Example 2

A heat treatment was performed for the melt-blown non-woven fabric described in Application Example 1 under a constant length at a temperature of 120°C for 1 minutes. The crystallinity of the non-woven fabric produced was 6% and the thermal shrinkage factor was 4%. The stress-strain curve of the non-woven fabric produced is shown in Fig. 2b. As in the case of application example 1, the non-woven fabric produced exhibits excellent flexibility as well as excellent elongation properties.

Comparative Example 1

Measurement was performed for the stress-strain curve and shrinkage factor on a hydrothermal plane for the melt-blown non-woven fabric described in the application example without a heat treatment. The crystallinity of the non-woven fabric produced was 4% and the thermal shrinkage factor was 70%. The stress-strain curve of the non-woven fabric produced is shown in Fig. 2c. The non-woven fabric produced exhibits adequate flexibility, but the shrinkage factor on a hydrothermal plane is high and elongation strength is low, thus, it is not suitable for practical application.

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Comparative Example 2

A heat treatment was performed for the polyethylene terephthalate melt-blown non-woven fabric described in Application Example 1 under a constant length at a temperature of 120°C for 10 minutes. The crystallinity of the non-woven fabric produced was 40% and the thermal shrinkage factor was 2%. The stress-strain curve of the non-woven fabric produced is shown in Fig. 2d. The non-woven fabric produced exhibits a low shrinkage factor on a hydrothermal plane but flexibility is inadequate and elongation strength is low; thus, rupturing is likely to occur during the course of production and it is not suitable for practical application.

Brief description of figures

Fig. 1 shows the change in crystallinity, shrinkage factor on a hydrothermal plane, versus heat-set treatment time under constant length for a melt-blown non-woven fabric made of a polyethylene terephthalate fiber; Fig. 2 shows the stress-strain curves for melt-blown non-woven fabrics made of polyethylene terephthalate fibers.

[Fig. 1]

Vertical axis:

Left side: Crystallinity (%)

Right side:

Left scale: Rupture elongation (%)

Right scale: Shrinkage factor on a hydrothermal plane (%)

Horizontal axis: Treatment time (min)

Solid line: Crystallinity

Dashed line: Rupture elongation

Broken line: thermal shrinkage factor

[Fig. 2]

Vertical axis: Stress (kg)

Horizontal axis: Elongation (%)